

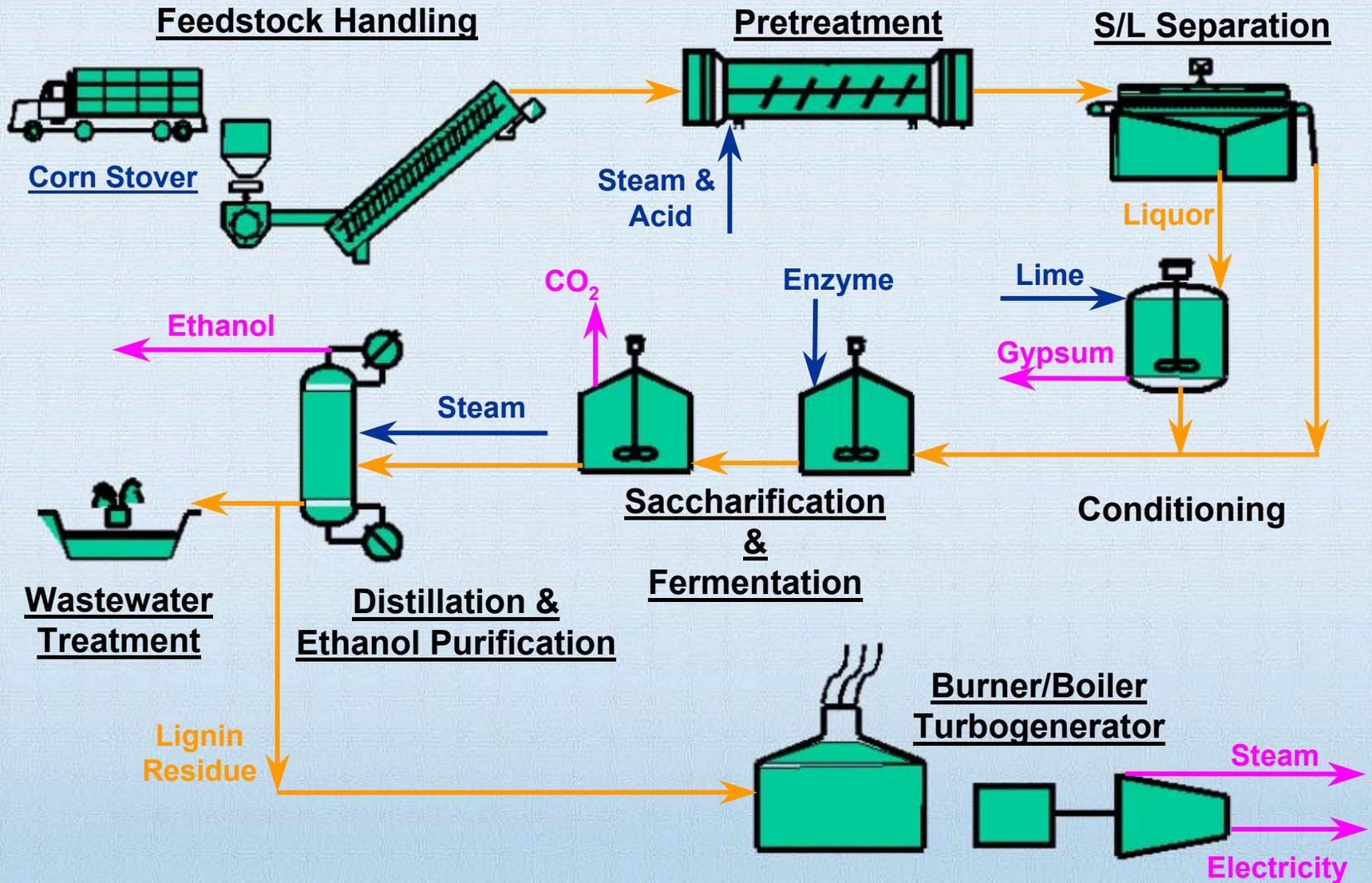
# The Effect of Corn Stover Composition on Ethanol Process Economics

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- Understand the effect of feedstock composition on results from techno-economic assessments
- Begin to develop confidence intervals around results from techno-economic assessments



- In 2002, NREL published an updated target-case design report
  - Greenfield corn stover to ethanol process
  - NREL/TP-510-32438
  - [www.nrel.gov/docs/fy02osti/32438.pdf](http://www.nrel.gov/docs/fy02osti/32438.pdf)
- Minimum Ethanol Selling Price (\$ per gallon ethanol) is the primary result



# Design Case Economic Results

Plant Size: 2200 tons (2000 MT) Dry Corn Stover/Day (Greenfield Site)  
Corn Stover Cost: \$30/dry ton

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<b>Economic Parameter (Units, \$2001)</b>	<b>Value</b>
<b>Minimum Ethanol Selling Price (\$/gal)</b>	<b>\$1.07</b>
<b>Ethanol Production (MM gal/yr)</b>	<b>69</b>
<b>Ethanol Yield (gal/dry ton stover)</b>	<b>90</b>
<b>Total Project Investment (\$ MM)</b>	<b>\$197</b>
<b>TPI per Annual Gallon (\$/gal)</b>	<b>\$2.86</b>
<b>Production Cost (\$/gal)</b>	<b>\$0.58</b>

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# Design Case Stover Composition

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<b>Carbohydrates</b>	<b>% dry basis</b>
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<b>Glucan</b>	<b>37.4%</b>
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<b>Xylan</b>	<b>21.1%</b>
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<b>Arabinan</b>	<b>2.9%</b>
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<b>Galactan</b>	<b>2.0%</b>
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<b>Mannan</b>	<b>1.6%</b>
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<b>Total</b>	<b>65.0%</b>
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<b>Other Components</b>	<b>% dry basis</b>
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<b>Lignin</b>	<b>18.0%</b>
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<b>Ash</b>	<b>5.2%</b>
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<b>Acetate</b>	<b>2.9%</b>
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<b>Protein</b>	<b>3.1%</b>
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<b>Extractives</b>	<b>4.7%</b>
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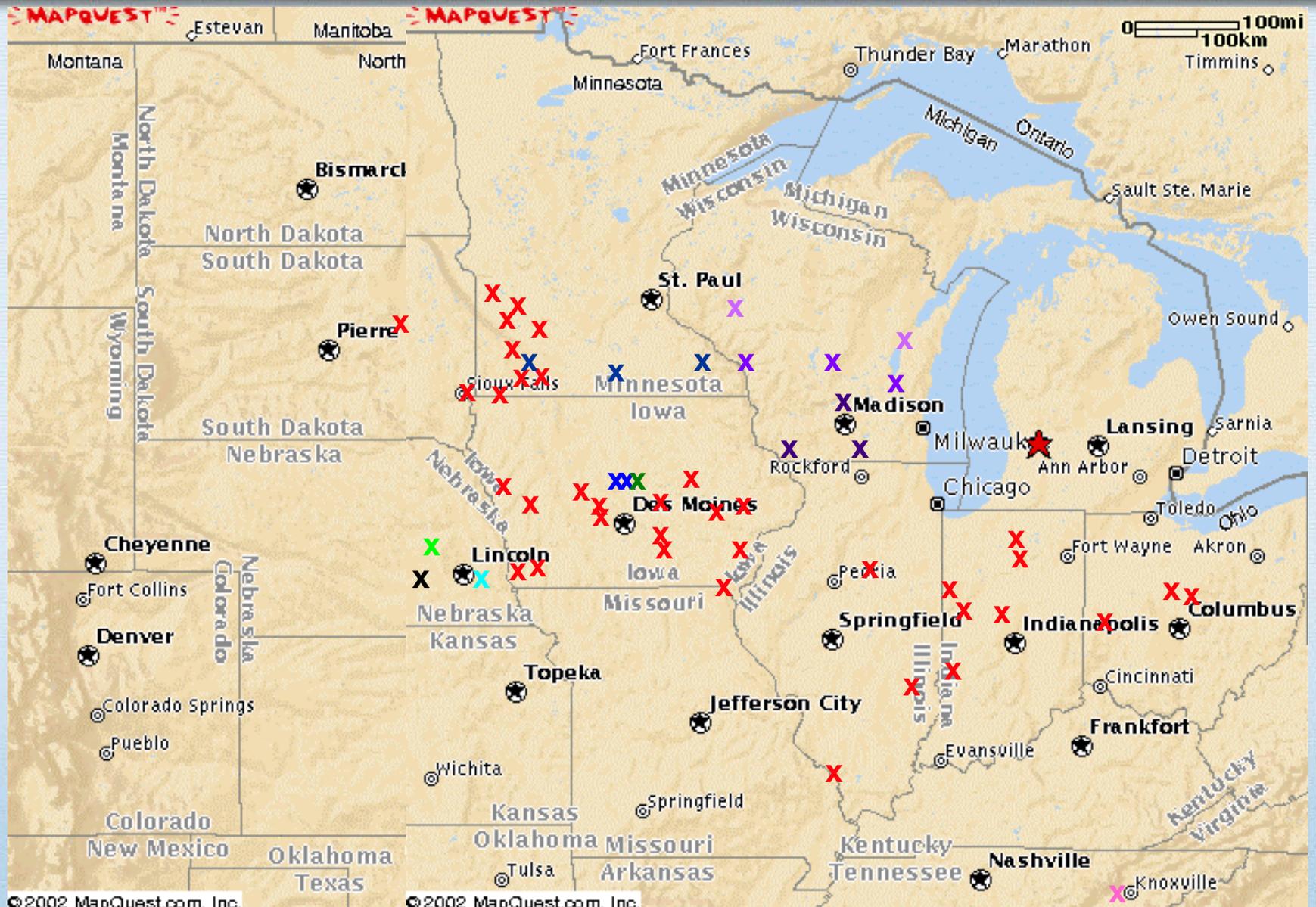
<b>Other</b>	<b>1.1%</b>
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- 112 hybrids
- 22 brands
- 52 sites in 10 states

- Asgrow
- Brown
- Dahlman
- Dairyland Stealth
- Dekalb
- Epley Brothers
- Garst/AgriPro
- Hoegemeyer
- Jung
- Kruger
- Midwest
- Mycogen
- NC+ Hybrids
- Northrup King
- Pioneer Hi-Bred
- Ramy
- Stauffer
- Viking
- Wilson
- Wyffels

# Stover Collection Locations

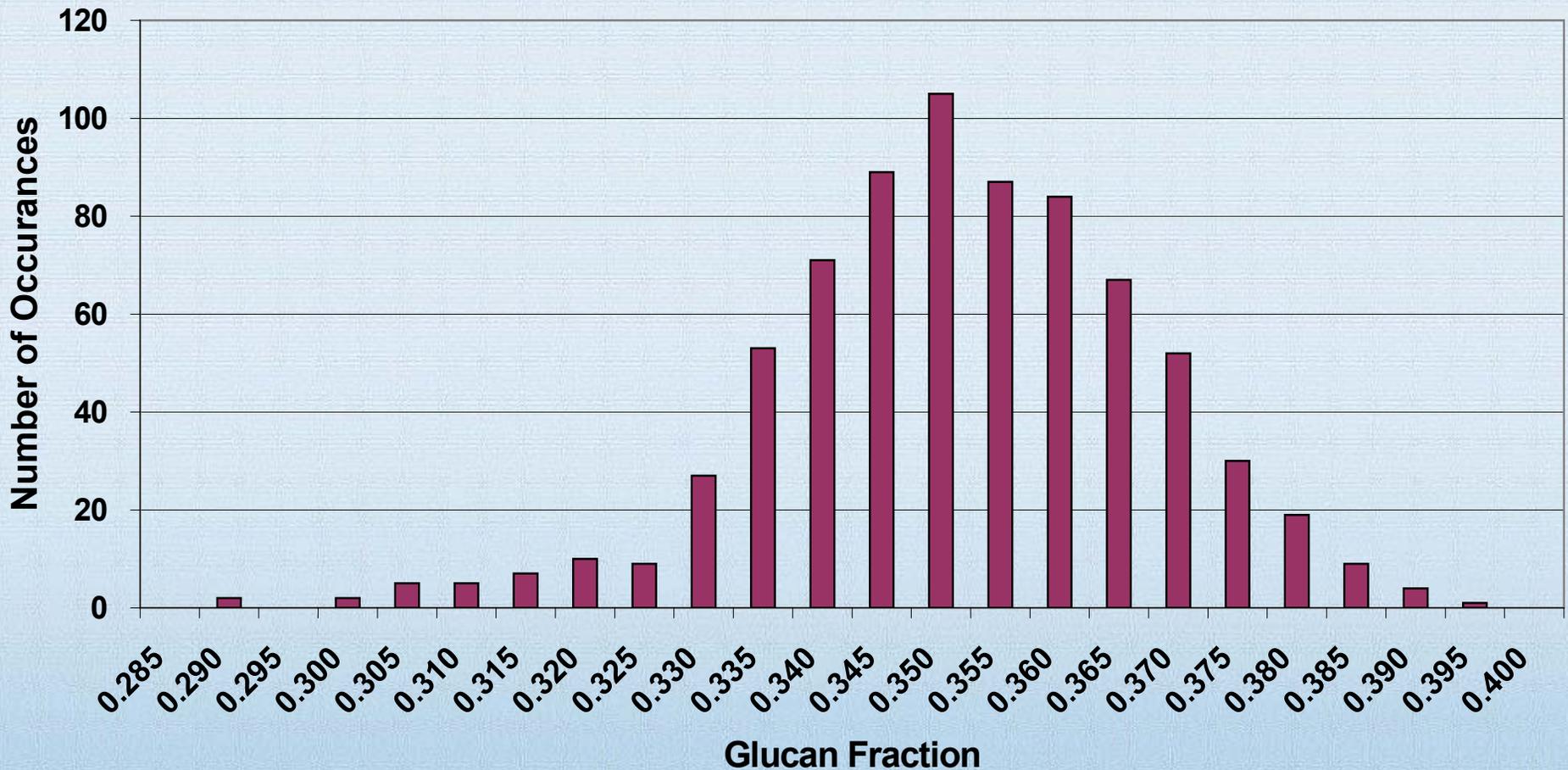




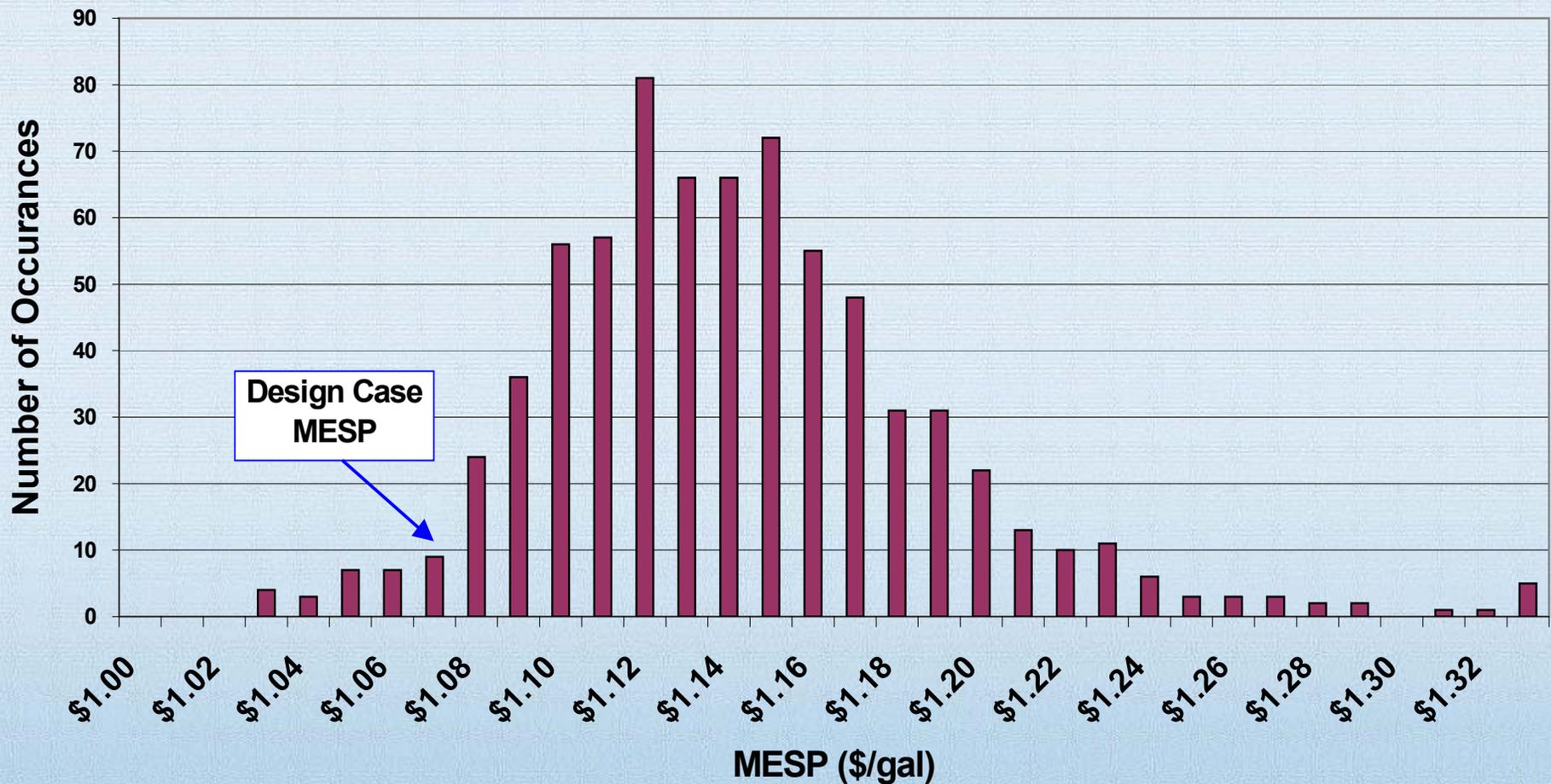
# Composition Ranges

	Structural Glucan	Xylan	Lignin	Protein	Acetyl	Uronic Acids	Structural Inorganics (Silica, Ash)	Soil	Soluble Solids	Total
<b>Minimum</b> (% dry wt.)	<b>27.9</b>	<b>14.5</b>	<b>11.5</b>	<b>1.3</b>	<b>0.9</b>	<b>1.4</b>	<b>-1.2</b>	<b>0.9</b>	<b>2.0</b>	<b>90.0</b>
<b>Maximum</b> (% dry wt.)	<b>39.6</b>	<b>25.5</b>	<b>20.4</b>	<b>7.0</b>	<b>3.9</b>	<b>3.9</b>	<b>10.2</b>	<b>1.7</b>	<b>19.6</b>	<b>101.9</b>
<b>Span</b> (% dry wt.)	<b>11.7</b>	<b>11.0</b>	<b>8.9</b>	<b>5.7</b>	<b>3.0</b>	<b>2.5</b>	<b>11.3</b>	<b>0.8</b>	<b>17.5</b>	<b>11.9</b>
<b>Mean</b> (% dry wt.)	<b>33.8</b>	<b>20.0</b>	<b>15.8</b>	<b>3.6</b>	<b>2.7</b>	<b>2.9</b>	<b>4.2</b>	<b>1.3</b>	<b>8.2</b>	<b>97.4</b>
<b>Standard Deviation</b> (% dry wt.)	<b>2.0</b>	<b>1.6</b>	<b>1.4</b>	<b>0.7</b>	<b>0.5</b>	<b>0.3</b>	<b>1.6</b>	<b>0.1</b>	<b>2.2</b>	<b>1.7</b>

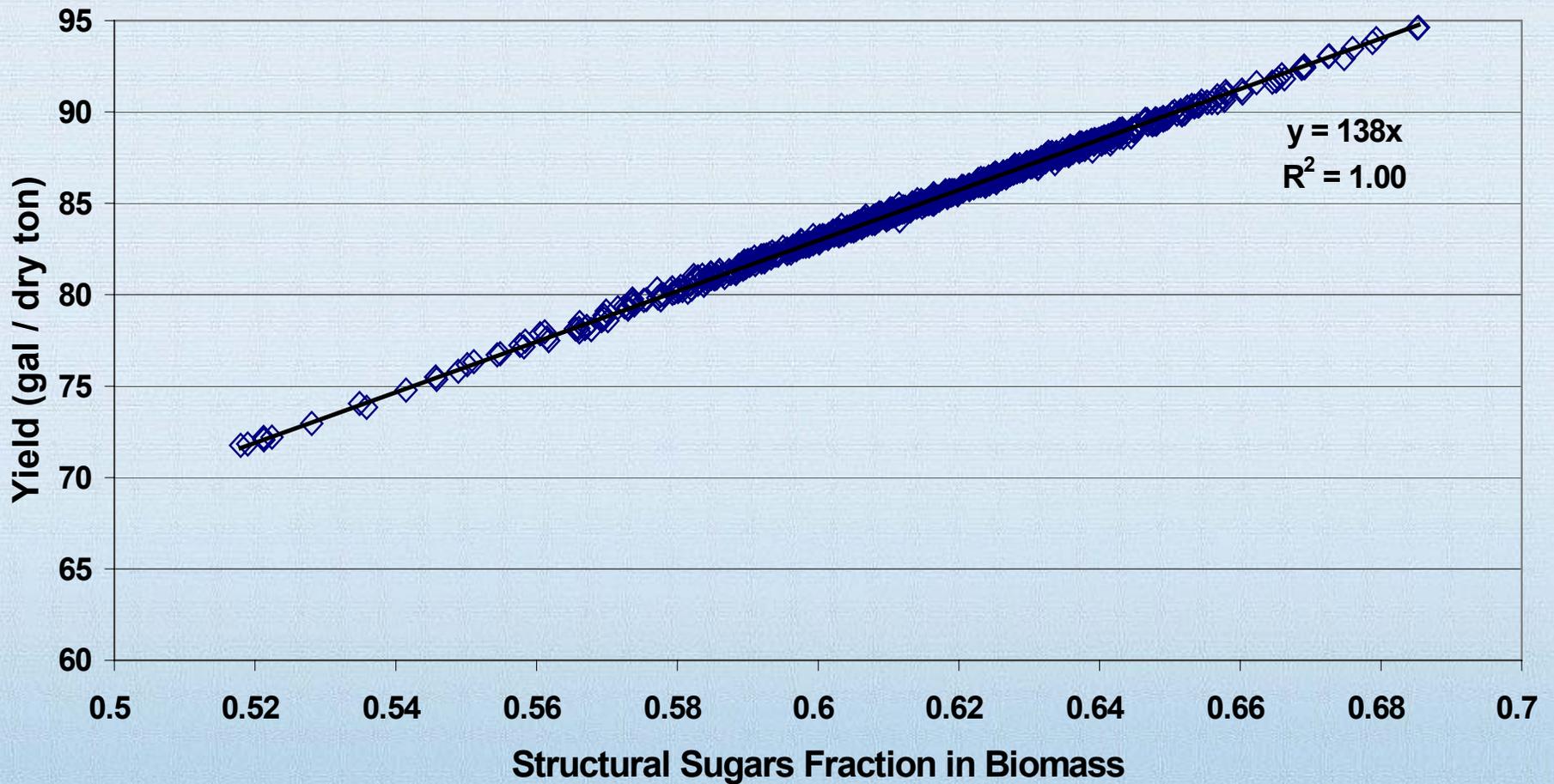
## Normalized Structural Glucan Distribution



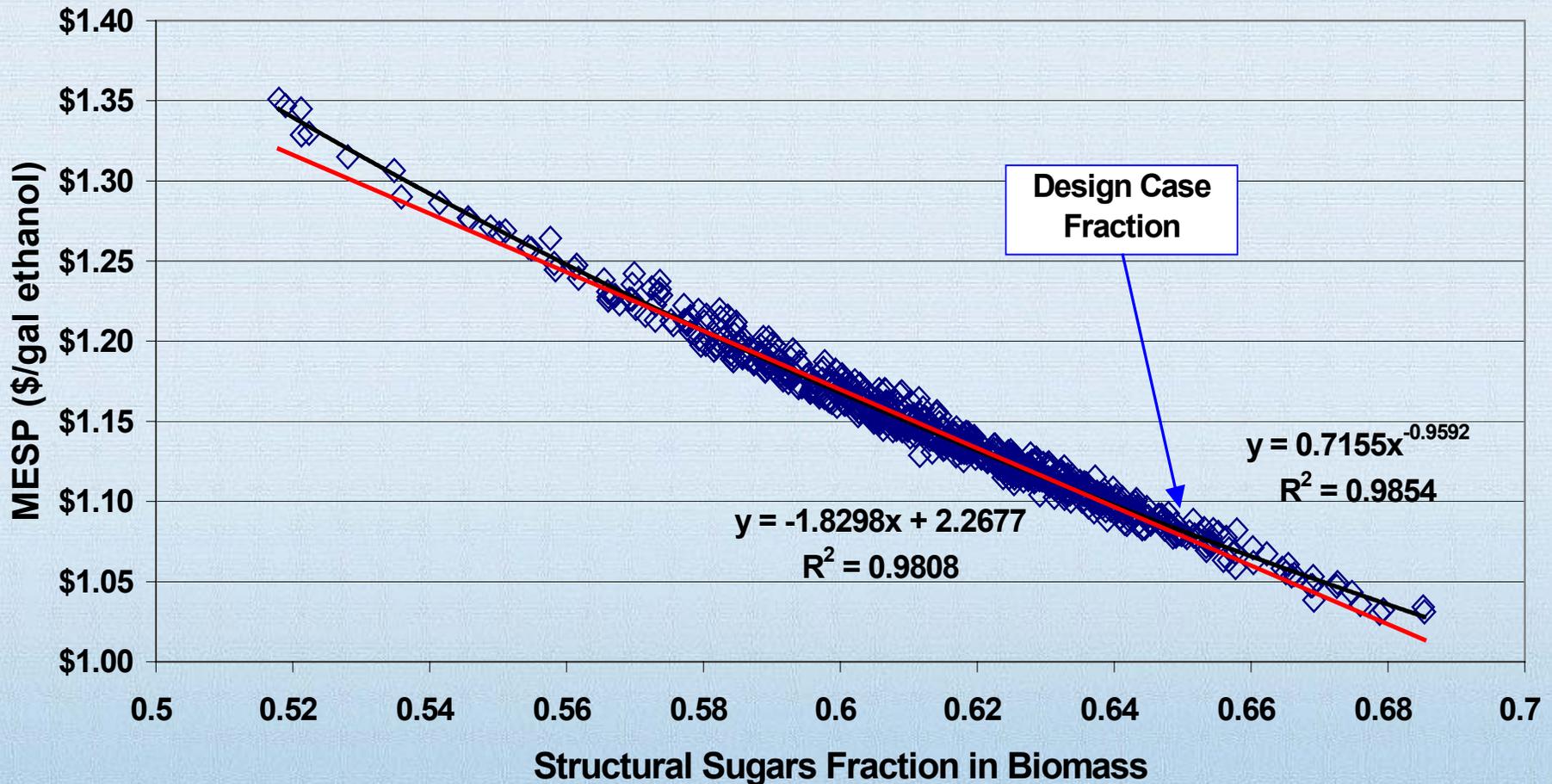
## MESPs for 735 Stover Compositions



## Structural Sugars' Effect on Yield



## Structural Sugars' Effect on MESP

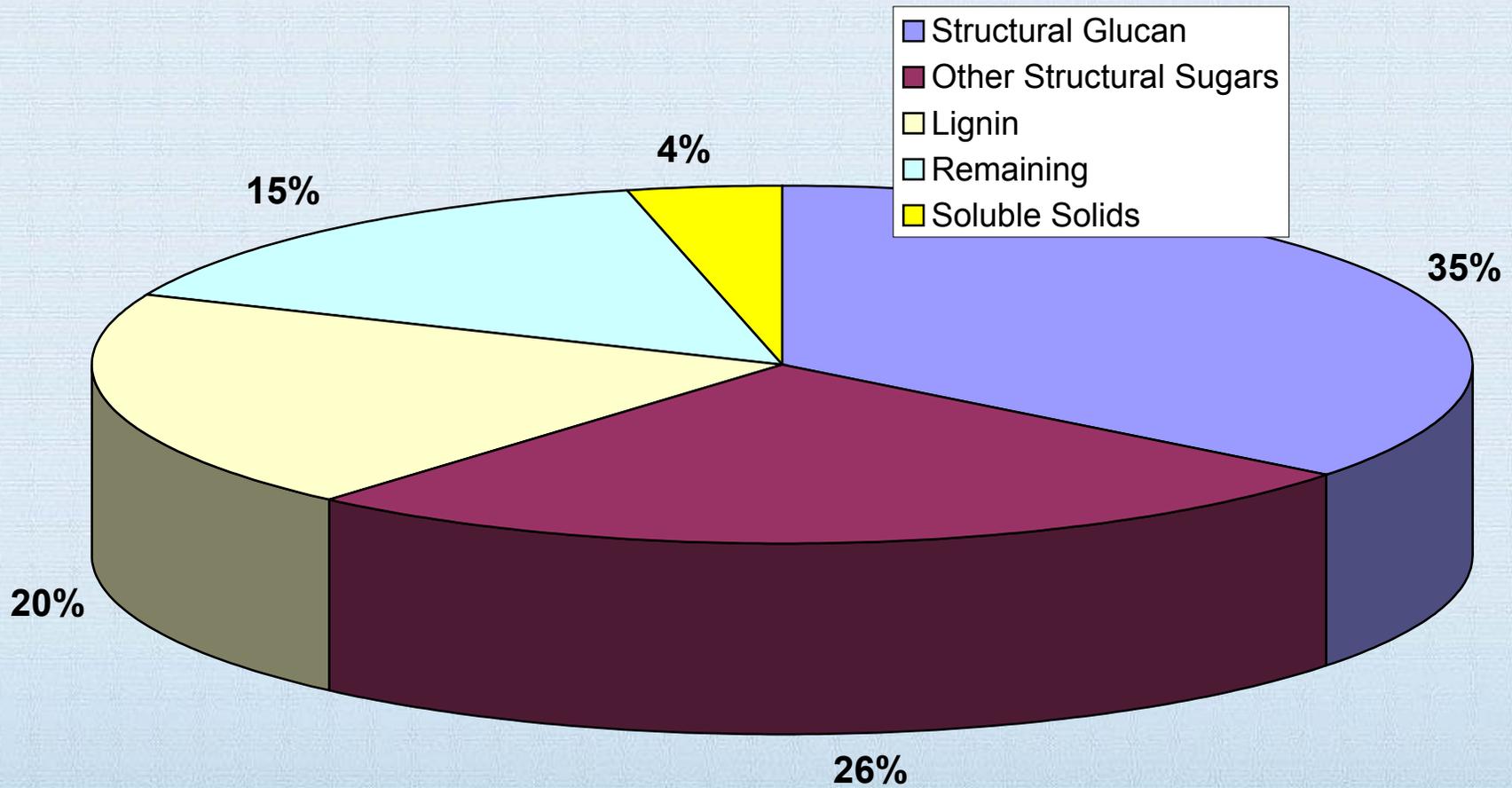


- Uses random numbers within defined functions to predict the uncertainty of modeled systems
  - Packaged software (e.g., Crystal Ball) makes it easier with Excel
- Used in the environmental, safety, business and other fields

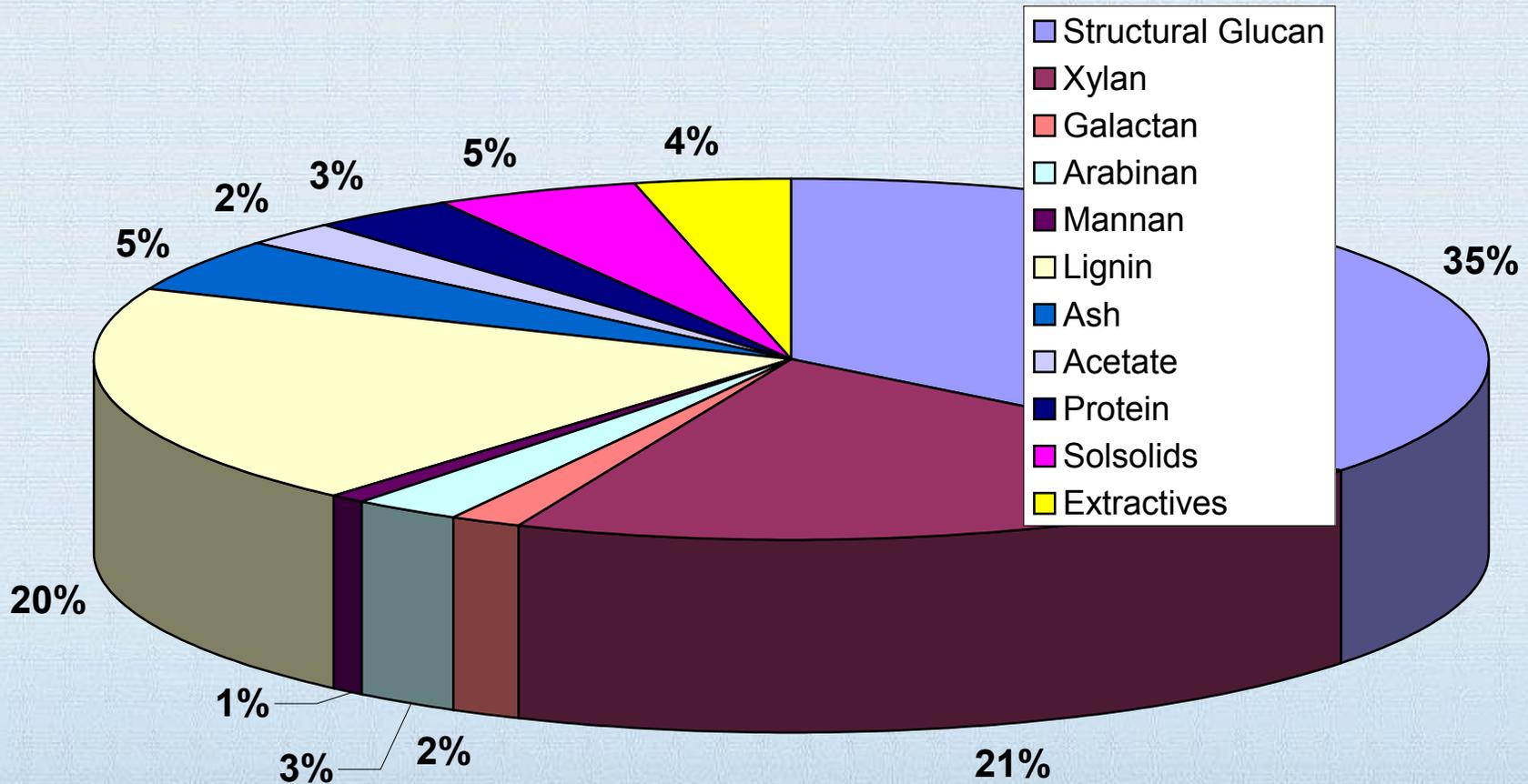


# Feedstock Probability Functions

- Structural glucan
- Other structural sugars
- Xylan fraction of other structural sugars
- Lignin
  
- Constant ratios
  - Galactan/mannan/arabinan
  - Ash/acetate/protein/soluble solids

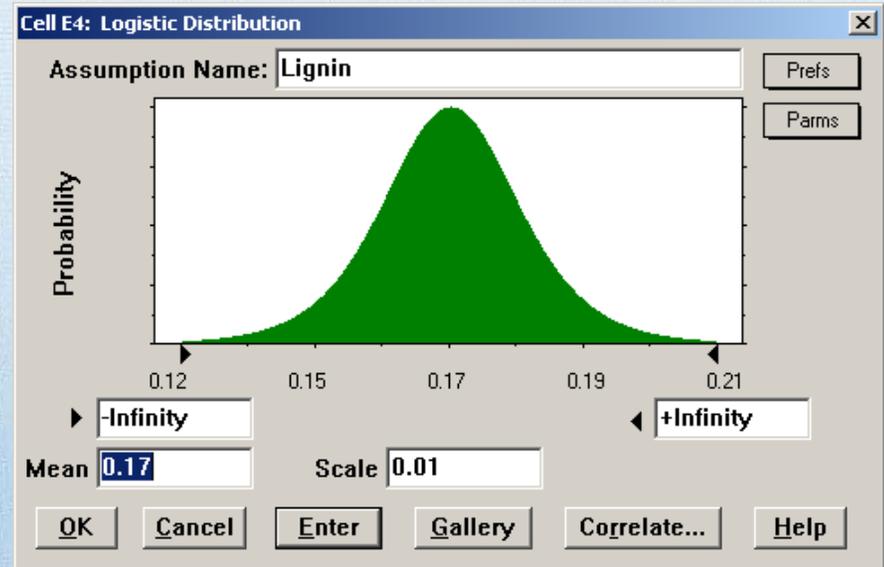
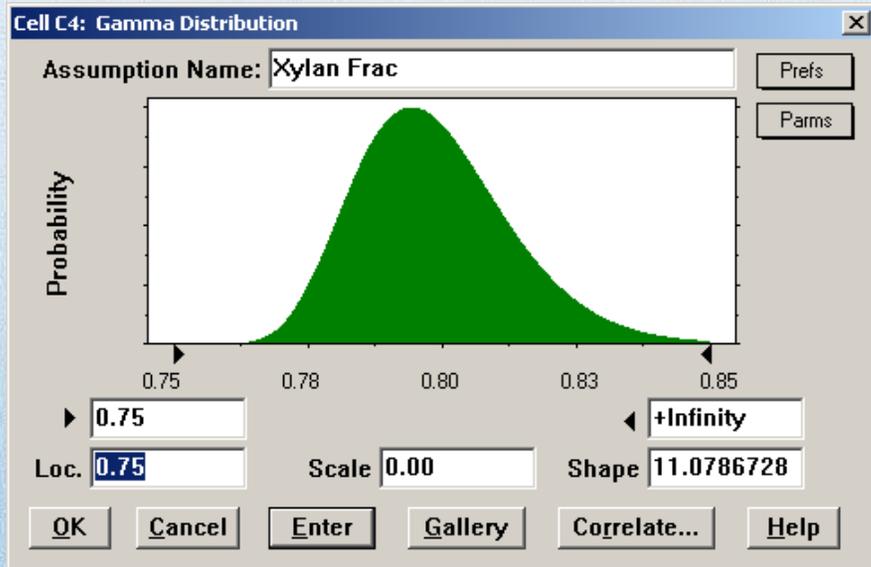
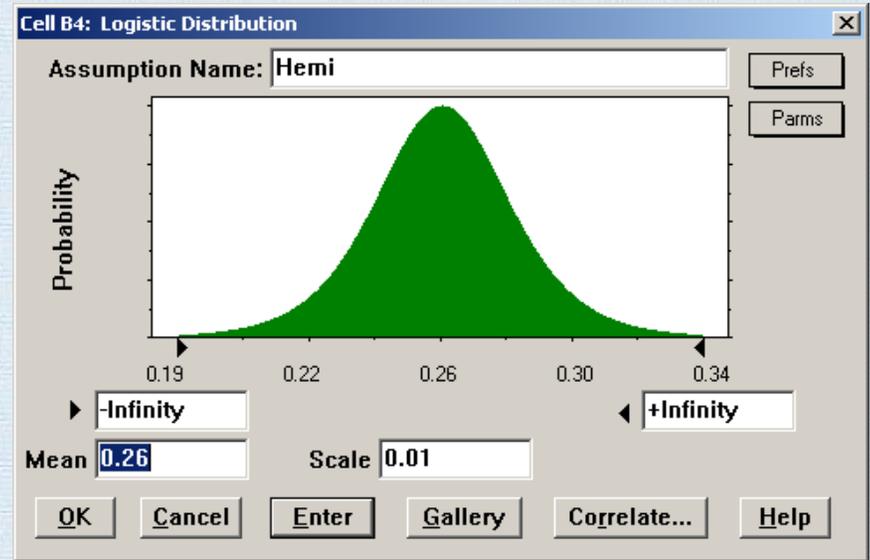
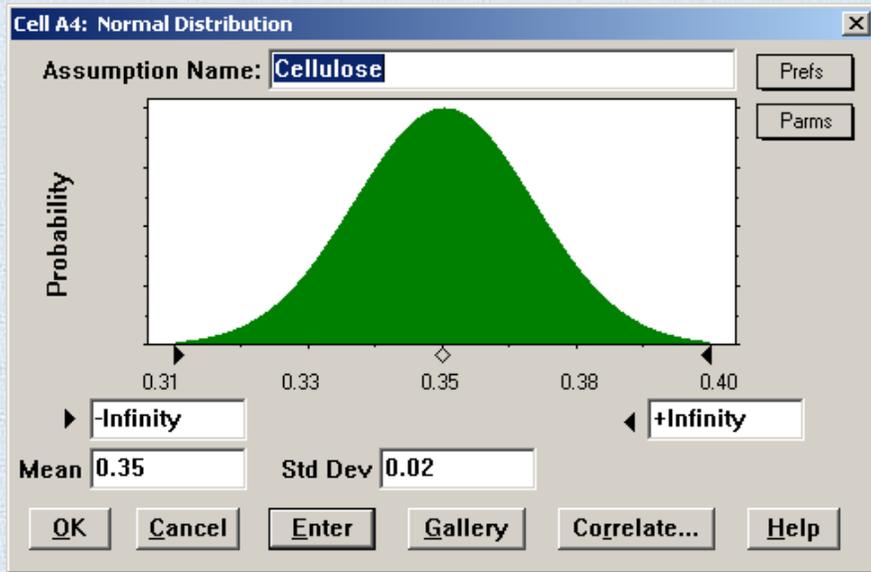


# Component Breakdown



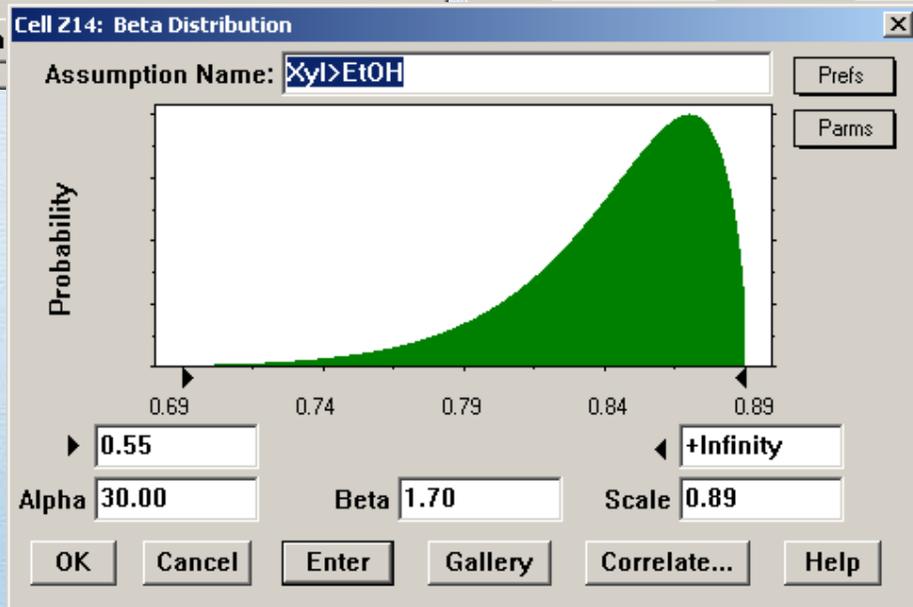
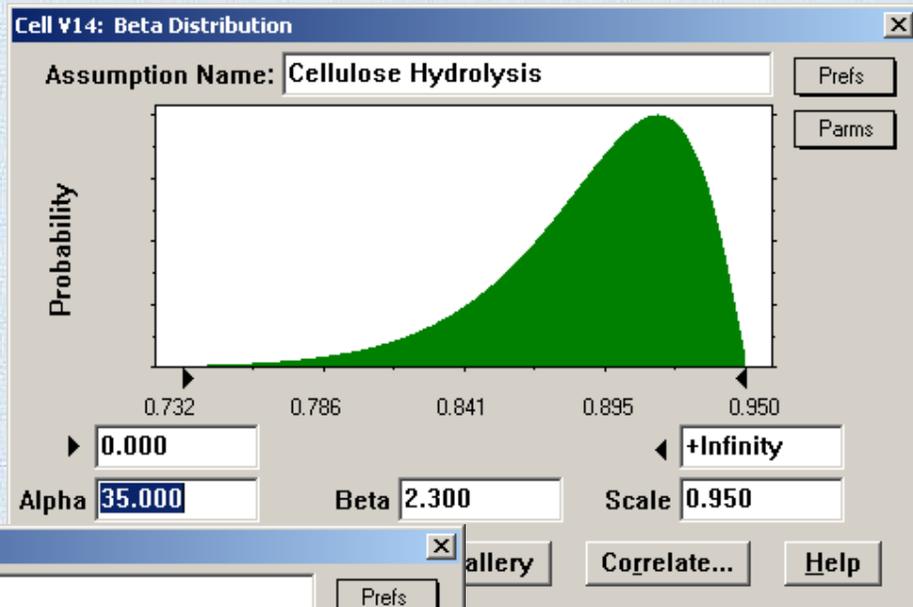
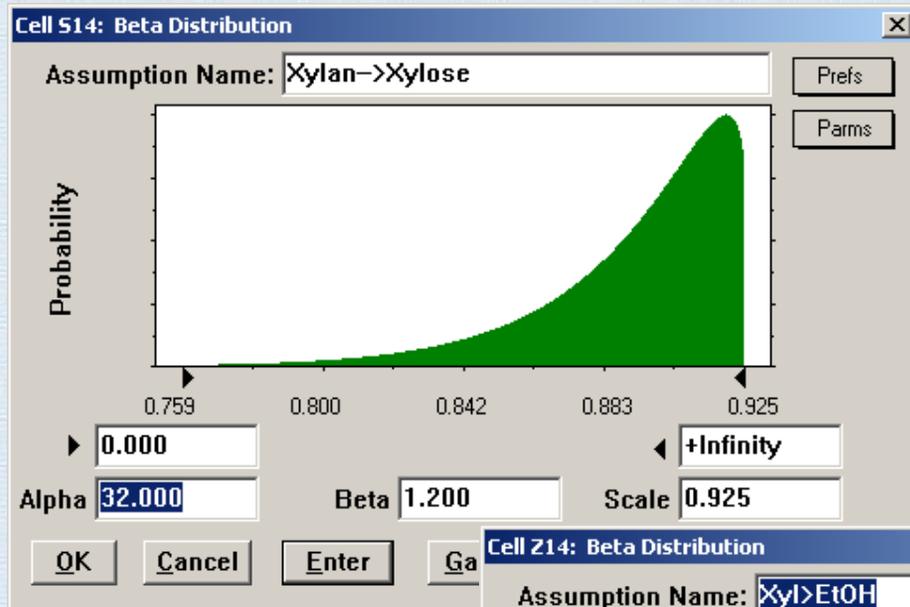


# Feedstock Probability Distributions



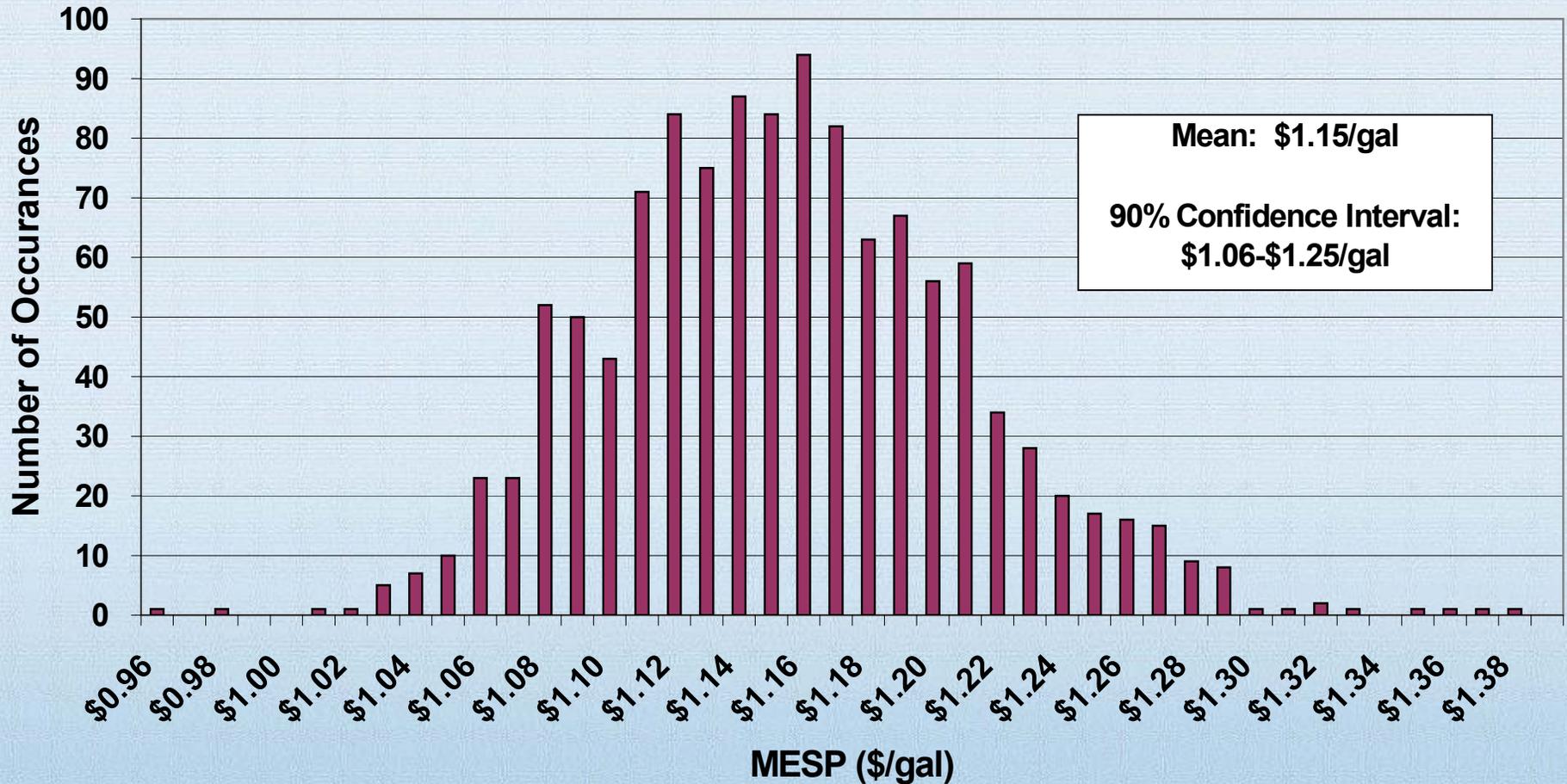


# Yield Probability Distributions



Gallery Correlate... Help

## Histogram of MESP for 1195 Monte Carlo Simulation Runs



- A carbohydrate change of 1% (of total dry matter) changes MESP by \$0.018/gal (within stover ranges)
- Monte Carlo is useful for confidence interval estimates
  - Reams of data improve function definition but estimates can be useful
  - This analysis gave an interval of \$1.06-\$1.25/gal

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